The American Sand Burrowing Mayfly

Dolania americana

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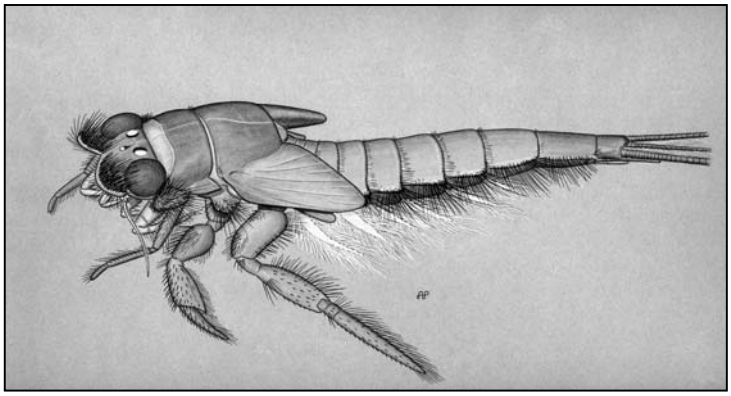


DESCRIPTION

Taxonomy and Basic Description

The American sand burrowing mayfly was originally described by G.F. Edmunds and J.R. Traver in 1959 from South Carolina based on the aquatic larva, which was the only stage known at that time. Eggs were first described in 1964 by R.W. Koss and adults were first described in 1971 by W.P. McCafferty. This remains the only named species of the strictly American genus *Dolania*. It is a member of the Northern Hemisphere family Behningiidae (the tuskless burrowing mayflies), of the infraorder Palpotarsa, suborder Furcatergalia, order Ephemeroptera (McCafferty 2004). Behningiidae are one of the smallest families of mayflies, with a total of three genera and six species known worldwide.

The Ephemeroptera, or mayflies, are primitive insects that, along with the dragonflies (Odonata), are considered Paleopterous insects; as such, they are not able to fold their wings, as are all other modern insects. Mayflies are aquatic insects, with both the eggs and larvae residing in freshwater. As such, mayflies are a major component of communities of invertebrates that live on or in the bottom substrates of streams and shallow zones of lake and ponds. Mayflies are unique among insects in that in their life cycle, they have a fully winged pre-adult stage known as a subimago as well as a fully winged adult stage. In all other winged insects the fully winged condition is restricted to the reproductively mature adult stage. Both the subimago and adult stages do not feed and are terrestrial (aerial) rather than aquatic. The name of the order is based on the word “ephemeral” and is an allusion to the fact that most mayflies have a generally very short adult life span (less than an hour in some).

Eggs of mayflies are generally oval in shape and usually have a sticky covering or string-like attachment structures that help them become attached to bottom substrates after being deposited on the surface of water by females. The females of most mayfly species produce from 500 to 4,500 eggs. While the eggs of Behningiidae are the largest known for mayflies, as much as 1.0 millimeter (0.04 inches) in diameter, each female American sand burrowing mayfly carries only about 60 eggs, which is the lowest number known among mayflies (Fink et al. 1991).

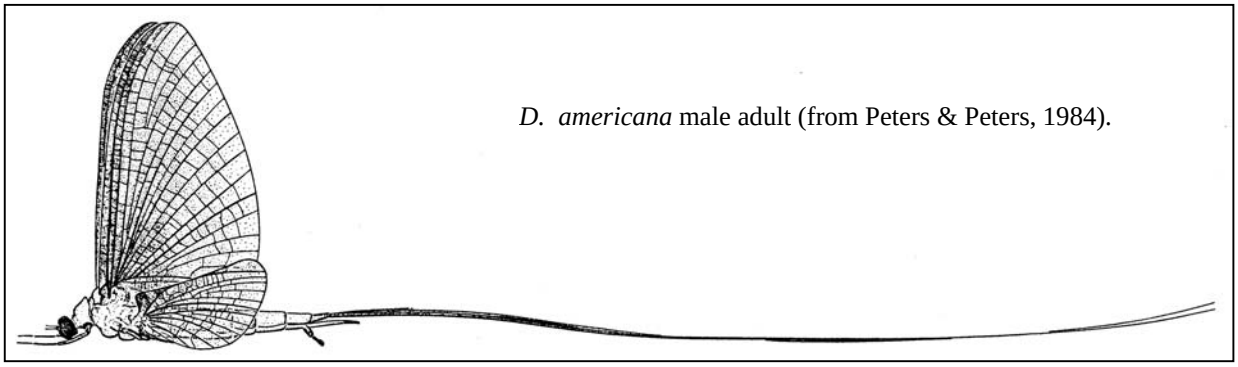
Larvae of mayflies demonstrate a large degree of diversity ranging from sleek minnow-like swimming forms to extremely robust crawling forms to highly flattened clinging forms. Behningiidae larvae are relatively large at nearly 1.5 centimeters long (0.6 inches), somewhat flattened, and have a large number of atypical mayfly characteristics that are associated with their burrowing in coarse sand and their predaceous feeding habits. Compound eyes and antennae of mayflies are well developed. Mayfly mouthparts are on the underside of the head

and show adaptations mainly for gathering small decaying material and diatoms, although some species have specializations for predation, filter feeding or scraping.

The Behningiidae are one of only a very few groups of mayflies that are predatory (Tsui and Hubbard 1979) and, in this respect, have unusually sharp mandibles and heavily muscled palps for impaling and manipulating prey. All mayfly larvae have wingpads associated with their three-segmented thorax (a larger pair on the second thoracic segment and a smaller inconspicuous pair on the third thoracic segment), and these wingpads become darkened just prior to molting to a fully winged form. In Behningiidae, the first pair of legs is palplike, the second pair is broad with well-develop spination, and the third pair is very long and has considerable spination. Unlike all other mayflies, Behningiidae larvae lack claws at the end of the legs. The absence of claws is probably related to the fact that the Behningiidae do not use their legs to crawl, but instead the legs have various raptorial or protective functions. On the 10-segmented abdomen of mayfly larvae, pairs of gills (one pair per segment) are present, usually on segments 1 through 7 or 2 through 7, with some reduction in numbers in certain mayflies. In Behningiidae, gills 2 through 7 are well-developed, each with a narrow-elongate leaflike portion that is fringed on either side with long filaments. Unusual for mayflies in general, the gills of Behningiidae are held underneath the abdomen rather than at the sides or above.

Mayfly larvae have either two or usually three tails (as in Behningiidae) at the end of the abdomen. The long, armed hindlegs of Behningiidae are held along the sides just below the abdomen so that they protect the gills from abrasion while the larva is immersed in coarse sand. Within this so-called gill chamber that is formed by the body and legs, the gills beat freely and steadily to aid in the uptake of dissolved oxygen from the water. The head and mouthparts of Behningiidae are also protected from abrasion, mainly by strong tufts of spines laterally and dorsally in that area of the body. Such tufts of spines are not found in other mayflies.

Both the subimagos and adults of mayflies are referred to as alates (bearing wings). The alates are fragile forms with vestigial, non-functioning mouthparts, small antennae, large compound eyes (more so in the males) and a pair of large, net-veined, more or less triangular shaped forewings and a smaller pair of hindwings. The wings are held together directly above the body when at rest. Forelegs of male adults are very long and aid in holding the female from below when mating. The abdomen ends in either two or three well-developed, often very long tails (see illustration immediately below). Differences are subtle between the subimago and adult stages.



D. americana male adult (from Peters & Peters, 1984).

The subimago has duller wings and cuticle and, in males, the forelegs, eyes and genitalia are not as well developed as they are in adults. Alates of Behningiidae are unusual mayflies in several

respects. Except for only a few other mayflies, the female subimago does not molt to an adult stage and is therefore reproductively mature and mates as a subimago. This is not the case with the male, having both a subimago and adult stage. Also, the legs of the alate Behningiidae are reduced and non-functional, so that these mayflies are unable to perch or walk about as most other mayflies can. While the two lateral tails are very long, the middle tail is considerably shorter and thinner.

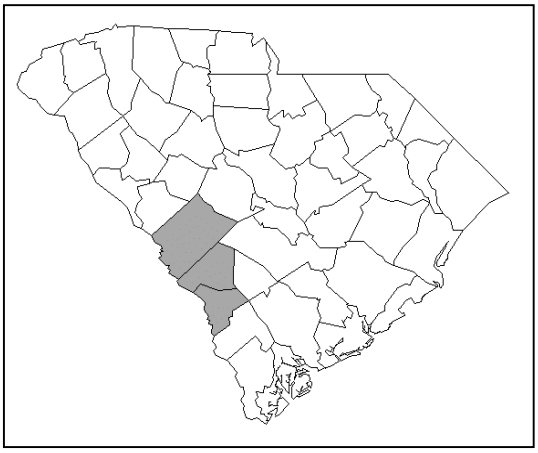
Mayflies generally have one, two or three generations per year. The American sand burrowing mayfly is unusual for mayflies in that it has a two year life cycle (Harvey et al. 1980). Alates of this species emerge from the water (hatch) consistently within about a 30-day period each spring or early summer, depending on the exact location of the populations. The hatch takes place in the pre-dawn hours, with males preceding females and soon thereafter molting to adults. Male adults mate with female subimagos as soon as the females begin to hatch. These insects may be the quintessential "ephemeral" mayflies in that, according to Peters and Peters (1984), this species emerges from the water, mates, lays eggs and dies within a few minutes.

Status

The American sand burrowing mayfly is known from Alabama, Florida, Georgia, Louisiana, North Carolina, South Carolina and Wisconsin. It currently has a global environmental ranking of apparently secure (G4). Although there are possibly six or more documented populations of the species in South Carolina based on different specific sites reported, it is ranked as vulnerable (S3) because it should be carefully monitored with respect to its somewhat unusual and specific habitat requirements and restrictions.

POPULATION DISTRIBUTION AND SIZE

The American sand burrowing mayfly is known from up to four populations with overlapping generations on Upper Three Runs Creek in Aiken County, but also from the Savannah River proper in Aiken, Barnwell and Allendale Counties. For South Carolina, only quantitative population data exist for the species on Upper Three Runs Creek (Sweeney and Vannote 1982). At the time of emergence, based on counts of larval skins on the water, around 2,800 individuals emerged in 1978, around 600 in 1979, and over 100,000 in 1980. More recent data for population size estimates are not available.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Little is known about the specific aquatic habitat requirements of the American sand burrowing mayfly at this time. Based on field observations and laboratory observations, one primary requirement is the presence of beds of coarse sand substrate wherein the larvae must reside. McCafferty (1975) showed that larvae burrow down in clean, well-aerated sand to a depth of 10

to 30 cm (4 to 12 inches), although it has been reported from shallower depths in the field (Tsui and Hubbard 1979). The gill chambers are maintained in coarse sand of 0.25 to 1.0 millimeters (0.001 to 0.03 inches), in diameter, but cannot be efficiently maintained in finer sand or silted substrates. The major food resource for the American sand burrowing mayfly is made up of midges that occur in this same habitat.

The aquatic insect fauna of Upper Three Runs Creek has been extensively documented (Morse et al. 1980, 1983). All 22 mayfly species reported from this stream have a global ranking of apparently secure (G4) or secure (G5) and are not considered at any level of risk at this time. However, with respect to mayflies that were expected but not found by Morse et al. (1980), those authors indicated that many hours of specialized sampling are needed to obtain even a small number of individuals of some species, including the American sand burrowing mayfly.

In addition to consuming a variety of sand-dwelling midge larvae (Diptera: Chironomidae), the American sand burrowing mayfly also preys on microcrustacea, biting midge larvae (Diptera: Ceratopogonidae), nematodes, and occasionally tartigrades. One competitor for the same food resources has been identified as a *Progomphus* dragonfly (Odonata: Gomphidae) (Tsui and Hubbard 1979). Some fish and whirligig beetles (Coleoptera: Gyrinidae) will prey on the American sand burrowing mayfly. Further, terrestrial predators of this species include nighthawks, sparrows, bats, dragonflies and spiders (Sweeney and Vannote 1982).

CHALLENGES

Cedar Creek, which arises in Aiken, South Carolina, is the main tributary to Upper Three Runs Creek. It is expected that the considerable residential development along Cedar Creek has introduced sediments from excavation works and erosion, lawn-care chemicals from landscaping, and petrochemicals from roads. It has also led to reduced base flow rates and accentuated spates. The incursion or increase in artificial lights near the habitat is also a detriment to most mayflies in that they attract alates away from their natural breeding grounds, which incapacitate them and reduce population reproduction rates.

All reports of the American sand burrowing mayfly are from “clean” shifting sand in high quality water. Therefore, it is essential that water quality is maintained and that sedimentation be prevented. Such perturbations would alter necessary oxygen levels in the water and the coarse sand burrowing substrate required by the species and its prey. The fact that the American sand burrowing mayfly does not occur between upper Wisconsin/Minnesota and the lower southeast, as other sand dwelling mayflies such as *Pseudiron* and *Acanthametropus* do is probably because intervening riverine sand substrates are too fine, such as those associated with the Wisconsin River in lower Wisconsin, the Niabrara River in Nebraska, the Pecatonica River in Illinois and the White River in Indiana.

CONSERVATION ACCOMPLISHMENTS

Upper Three Runs Creek is protected at the Savannah River Site; however, a variety of off-site anthropocentric activities as discussed above have degraded water and substrate quality in Upper Three Runs Creek in recent years. The extent of such degradation and any direct or indirect

effects it has had on the American sand burrowing mayfly at the Savannah River Site or elsewhere on the creek are unknown at this time, as is the degree to which any protection practices have offset the sum effects of such degradation.

CONSERVATION RECOMMENDATIONS

- Determine water quality in Upper Three Runs Creek, both upstream of and at the location of the American sand burrowing mayfly habitat, protect or restore superior water quality depending on results from this survey.
- Protect critical habitats for the American sand burrowing mayfly from future development and further habitat degradation by following best management practices and protecting riparian areas.
- Promote land stewardship practices through educational programs both within and upstream of Upper Three Runs Creek.
- Encourage responsible land use planning.

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